Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of	)	WT Docket No. 01-309
	)	RM-8658
Section 68. 4(a) of the Commission's Rules Governing Hearing Aid-Compatible Telephones	)	

NOTICE OF PROPOSED RULE MAKING

Comments of:
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I am an individual with severe to profound hearing loss. I have used the hearing aid telecoil feature with telecommunication equipment since 1984. The telecoil feature allows me to use telecommunication equipment where I could not otherwise. Attached to these comments is a report I call "Digital Wireless Phone Interference to Hearing Aids" which includes oscilloscope waveforms I captured in several experiments over the past year. Even though my report may appear technical, I am not an engineer. I thank the FCC for the opportunity to submit these comments.

I. INTRODUCTION

1. In this Notice of Proposed Rulemaking, we reexamine our exemption, pursuant to direction of the Hearing Aid Compatibility Act of 1988, of public mobile service phones from the hearing aid compatibility requirements of that Act. This Notice is being taken pursuant to our obligation under that Act to assess periodically whether the exemptions from the hearing aid compatibility requirement continue to be warranted.

2. Currently, many people who use hearing aids or who have cochlear implants have difficulty finding a digital wireless mobile telephone that functions effectively with those devices because of interference and compatibility problems. Requiring public mobile service devices to be made compatible with these devices would ensure that people with hearing disabilities would be able to enjoy the same access to wireless communications that other consumers do. In this Notice, we explore the extent to which the exemption for public mobile service telephones is still appropriate and whether it needs to be limited under the statutory standards to enable hearing aid users to benefit from the convenience and features offered by digital wireless communications systems. Based on preliminary evidence presented to the Commission, we initiate this proceeding to seek comment on whether public mobile service telephones should be required to be hearing aid compatible.

4. The statute requires that, unless exempt, all essential telephones and those manufactured in or imported for use in the United States after 1989 must "provide internal means for effective use with hearing aids that are designed to be compatible with telephones which meet established technical standards for hearing aid compatibility." In addition, the statute directs this Commission to assess periodically the appropriateness of continuing the exemptions. Specifically, the statute requires us to revoke or otherwise limit the exemptions if we determine that

(i) such revocation or limitation is in the public interest;

(ii) continuation of the exemption without such revocation or limitation would have an adverse effect on hearing-impaired individuals;

(iii) compliance with the requirements of [the rule] is technologically feasible for the telephones to which the exemption applies; and

(iv) compliance with the requirements of [the rule] would not increase costs to such an extent that the telephones to which the exemption applies could not be successfully marketed.

I will comment on each of these items with my main emphasis on item (iii) for which I have prepared a separate report from data gathered over the past year. I titled the report "Digital Cell Phone Interference to Hearing Aids" and it is included at the end of my comments.

1. Public Interest

20. Under the language of the statute, we seek comment first on whether revoking or limiting the exemptions is in the public interest. Industry commenters argue that alternatives are available to persons with hearing disabilities, such as wireless analog services and external devices that permit hearing aid users to utilize wireless digital services. For example, some equipment manufacturers have developed neckloop sets as a short-term solution that make it possible for people who have telecoils in their hearing aids to use digital wireless telephones. Consumer advocates assert that analog services are not a satisfactory alternative because they are difficult to find, suffer from occasional static and disconnection, are not as secure as digital services, do not offer nearly as many features, do not conserve battery life as well as digital, are more expensive, and are on networks that are not as well maintained and cannot accommodate rapid subscriber growth. We note that, while the Commission's rules currently require cellular systems to provide analog service, the Commission is considering whether to eliminate or modify this rule. Consumers and consumer groups also express dissatisfaction with external devices, such as neckloops, because they are expensive, cumbersome, and inconvenient. Neckloops are not an option for many hearing aid users because only about 20 percent of hearing aids contain a telecoil, which is necessary for electromagnetic coupling with the neckloop. In addition, according to TDI, because not all digital wireless telephones will work with all accessories, hearing aid users have a limited choice of telephone models and, often, service providers, putting them at a practical and economic disadvantage. As a result, many consumers consider these external devices unsuitable as a long-term solution. Moreover, as we have already indicated, it does not appear that external components such as neck loops can satisfy the statutory requirement that compatibility must be provided through "internal means."

One way to achieve hearing aid compatibility is to require service providers to continue to provide analog service. Most wireless phones on the market today can operate in either digital or analog mode, but it is impossible to switch to analog, or set up the phone in analog mode for speech and use digital mode

for everything else. Since analog mode does not cause interference, that approach would make it relatively easy to achieve internal HAC. I am not suggesting that hard of hearing people be limited to analog-only wireless phones. It is just an observation that if the interference problem cannot be solved in any other way, this approach would solve it.

Regardless of whether a phone achieves compatibility internally or achieves it with a neckloop, a telecoil is required in the hearing aid. If only 20% of hearing aids have a telecoil, both methods of achieving compatibility will be affected to the same 20%. Rather, a neckloop is not a good option because it is extra gear that has to be worn and maintained. Neckloops used with wireless phones are more than just neckloops, and they are usually called "Loopsets". They contain an amplifier which requires a battery. Since the Loopset is small, a small battery is used that runs out at the most inopportune time. Public interest would be served if hard of hearing people could wear the wireless phone or contain it in a pocket or purse like everyone else, and get it out when a call is received. Many times there is not enough time to get all the extra equipment in place and connected be able to answer the call. Hard of hearing people are not an easily identified group. We are in society just like everyone else — going to school, working, playing, or enjoying retirement. We are in all walks of life, all occupations, and have the same needs for instant and convenient telecommunications as people that do not have hearing loss.

21. As noted by some parties, the Commission's Fifth Competition Report on Commercial Mobile Services contains evidence that wireless analog service is declining and is being supplanted by more efficient, feature-rich digital services that are offered at competitive prices. It appears this trend is likely to continue. As a result, the wireless options for people who are hard of hearing are becoming increasingly limited, while choices for people who are able to use digital wireless devices are growing. Revocation or limitation of the exemptions would benefit people with hearing disabilities by allowing them access to digital wireless services, enabling them to more fully participate in employment opportunities and daily life. Requiring public mobile service telephones to be hearing aid compatible could provide hearing aid users with additional communications choices at a lower cost because of the efficiencies of digital services. For these reasons, we tentatively conclude that limiting the exemptions to require devices used with public mobile service to be hearing aid compatible would serve the public interest. We seek comment on this tentative conclusion.

Many hard of hearing people are highly successful and competitive with their peers. To remain competitive, they must have access to technological wonders, with the same level of convenience and usability. At the same time, some hard of hearing people face struggles with any kind of phone, not just wireless phones. They are at an economical disadvantage because of phones. It is a disservice and not in the public interest for them to pay extra for accessories to make a digital wireless phone usable, or to require them use analog-only wireless phones that have fewer features at a higher cost. As a futurist, I foresee the day when everybody will be using wireless phones and landline phones will be obsolete. A method may be developed whereby delivering residential service is based on a form of digital wireless service and copper wire to the residence will not be available. For these reasons, I support your tentative conclusion that making digital wireless phones HAC is in the public interest. If there are any technical barriers in doing this, then those problems need to be solved now, because solving the problem later may be much more extensive.

2. Effect on People With Hearing Disabilities

22. We seek comment on whether the continuation of the exemptions without revocation or limitation would have an adverse effect on people with hearing disabilities. As commenters have noted, digital wireless telephones offer many features that would benefit deaf and hard-of-hearing individuals, including short messaging service, email, and Internet access. It also can allow employees with hearing aids to work in the field and communicate with dispatchers and co-workers, greatly enhancing their ability to find employment opportunities and participate and communicate in the modern world. However, as long as the exemptions to the hearing aid compatibility rule continue in effect, the incompatibility between digital wireless devices and hearing aids and cochlear implants will continue to prevent users of these devices from having full access to digital wireless services and products. Many consumers have commented in this proceeding and have submitted complaints concerning their difficulties using digital wireless telephones. While external accessories are available that, in some situations, may allow access to some hearing aid or cochlear implant users, as we have discussed, these accessories are not universally available to or usable by all people with hearing disabilities, nor would they satisfy the statutory requirement that hearing aid compatibility must be provided through internal means.

23. With the growing prevalence of wireless digital telephones and declining availability of analog telephones, continuing the exemption for public mobile services would severely limit the communications options available to people with hearing disabilities. In addition to helping to ensure wireless access for the more than 28 million Americans with hearing loss, a number which continues to grow with the "graying" of the population, limitation or revocation of the exemptions would also benefit future generations of people with hearing disabilities as well. For these reasons, we tentatively conclude that continuation of the exemption without limitation or revocation would have an adverse effect on individuals with hearing disabilities. We seek comment on these tentative conclusions.

Some people who used to depend on Baudot TTY communication are now turning to pagers and wireless email. I, myself, use two line voice carry over (2LVCO) a good bit. Even when voice communication on a phone is good, I find that I must sometimes get help from Relay services like 2LVCO. It is a word discrimination problem. When I use 2LVCO, I need a phone that is very clear and free from extraneous noises. At home, I can achieve 2LVCO using my computer as the text line to Relay and a landline phone on another line as my voice line. When traveling, such as at a hotel room, I must use the hotel room landline phone with my laptop (or TTY) as the text line and a wireless phone as the voice line, because two lines are not generally available in a hotel room. The voice line has to be at least as good when traveling as it is when I am at home.

Digital wireless phones have the potential to offer clear voice and text services that will encompass the needs of a broad range of hearing loss. The potential is there for an ideal communication device that will meet the needs of people who can only use text, or who like to use text, and people who can use voice. It would be a serious setback to find that the ideal communication device that everyone is raving about and using creates so much noise that it is unusable by hard of hearing people in voice mode. It is a fact of life for many of us to have poor word discrimination, but it should not be a given that digital wireless phones make word discrimination so much worse because of the noise they generate. HAC is a great benefit in other phones because it cuts out the environmental noises and provides a direct, electronic coupling to the hearing aid, bypassing the acoustic path. HAC in a digital wireless phone would give the same benefit.

Besides using a wireless phone in connection with work and with family and friends, another use is for safety. It is very comforting to the general population to have a wireless phone to call 911 when an emergency occurs, such as a car breakdown, accident, mugging, or a medical emergency. People with hearing loss need that same level of easy communication without worrying about where the accessories are. The digital wireless phone needs to work dependably, all by itself, in a self contained package.

3. Technological Feasibility

24. We seek comment on whether compliance with the requirements of the hearing aid compatibility rule is technologically feasible for the telephones to which the exemption applies. To this end, we seek empirical data based on test results or other specific information concerning the technological feasibility of making wireless telephones hearing aid compatible. If testing has not been conducted, we seek comment on the types and nature of testing that would empirically demonstrate the feasibility of achieving such compatibility. According to the legislative history of the HAC Act, technological infeasibility means "impossible" or "undoable." The record developed in response to the Public Notice does not contain a high level of detail on this issue. A few consumer commenters suggest possible methods of achieving hearing aid compatibility, but they themselves acknowledge that further testing is needed. TIA and Verizon Wireless contend that technology has not yet advanced to the point where digital wireless handsets can be made hearing aid compatible with the vast majority of hearing aids.

There are two issues involved: Compatibility and Interference

Compatibility is achieved by employing a transmitting coil inside the phone that will send desired speech signals to the telecoil inside a hearing aid. This transmitting coil may take the form of a "dynamic" speaker which uses a coil and a magnet to produce sound, or an extra coil can be placed in the vicinity of the speaker. That is what it takes to make a phone "hearing aid compatible", and the signal strength must be enough to comply with part 68 rules.

The compatibility issue can be solved by most phones quite easily. Some very small phones may not have enough battery power to generate a sufficient compatibility signal. Since small phones have a small battery, talk time is reduced by having to generate the compatibility signal. However, many phones are quite robust and even have a "Speaker Phone" type of operation. Any phone that can boast a speaker phone has enough power to generate the compatible signal. To save battery power, phones could be designed so the user can choose which type of operation he or she wants, such as "Normal Acoustic", "Speaker Phone" or "Telecoil" (Compatibility). People who do not need the compatibility option would not experience reduced talk time.

I address the interference issue at quite some length in a report I call "Digital Wireless Phone Interference to Hearing Aids".

25. On the other hand, industry commenters indicate that the newly developed interference standard will facilitate the categorization of wireless products and hearing aids to make these de-

vices usable together. Industry commenters assert that, because hearing aids are uniquely fitted to optimize the hearing of the user, designs vary and make a "one size fits all" solution or standard difficult. These commenters also point out that the design of the hearing aid is beyond the control of the wireless industry, and that hearing aid manufacturers must play a role in achieving compatibility between hearing aids and digital wireless devices. As AG Bell notes in its comments, hearing aid manufacturers have attempted to respond to the digital incompatibility problem by boosting the interference immunity of most new models of hearing aids.

I do not believe it is possible to boost the interference immunity in the hearing aid itself, regarding HAC. When the hearing aid is in telecoil mode, which is necessary for HAC operation, the telecoil is "listening" for any and all signals in the audio band. It cannot distinguish between speech signals and interference signals. Hearing aids that are not in telecoil mode, or do not even have a telecoil may experience some interference, and immunizing them may be possible and desireable. That is an entirely different subject and is beyond the scope of this NPRM, since this NPRM is concerned with HAC which requires that a hearing aid be in telecoil mode. The emphasis should be on making digital wireless phones emit the compatibility signal at the level required by part 68 rules, and eliminating interference. If that is done, and certain hearing aids still do not function with the compatibility signal, then that is a fault with that model of hearing aid.

26. We seek comment on ways in which hearing aid manufacturers, digital wireless telephone manufacturers, and service providers can work together to develop long-term compatibility solutions. In addition, we seek comment on whether the "pairing" approach suggested by industry commenters would be satisfactory to hearing aid users and whether it would satisfy the technological feasibility condition such that the Commission could limit the exemptions. We also seek comment on whether this pairing approach, which is intended to reduce the interference between digital wireless devices and hearing aids, will resolve the compatibility issue.

No, I do not believe pairing will be a help, except for one possibility.

When the hearing aid is set for telecoil mode, it expects to receive audio frequency electromagnetic radiation, whether it is desired speech signals or undesired interference signals. It is non-selective. Interference also comes for common things such as computer monitors, fluorescent lights, motors, and transformers because those things operate on 60 Hz AC power. The telecoil picks up a 60 Hz hum. Interference from a digital wireless phone is similar to 60 Hz hum except the waveform is not a smooth sine wave. It is not an immunity problem within the hearing aid, because when the hearing aid is set for telecoil mode, there cannot be any immunity from external interference sources that are in the expected frequency range of the telecoil.

However, it may be possible for some hearing aids to be setup to reject all frequencies below a certain point when it is in telecoil mode. Newer programmable hearing aids may have this capability or future hearing aids may be possible with a sharp cutoff point. That would be beneficial for reducing interference from other sources as well. Landline phones do not carry any audio information below

300 Hz, and that has been the industry practice for years. I do not know the audio frequency response limits for digital wireless phones, but I see no need for them to carry audio information below 300 Hz. Therefore, it would not hurt to design a hearing aid to have a sharp cutoff at 300 Hz when in telecoil mode. Hearing aid users who use their telecoils with Assistive Devices may want a lower cutoff point to enjoy music, so future hearing aids could have two telecoil settings: One with a sharp cutoff of 300 Hz for telephone use, and another for Assistive Device/Music use.

27. We also seek comment more generally on possible methods of achieving compatibility between digital wireless telephones and hearing aids covered by the statute. For example, it would be useful to know whether there are ways to separate or shield the transmitter portion of a digital wireless telephone from the user's hearing aid in order to make the two components usable together. As noted by Verizon, given most customers' desire to own small portable wireless devices, the public interest would not be served by requiring manufacturers to separate the earpiece and the transmitter in all digital wireless telephones in the name of hearing aid compatibility. Moreover, this physical separation would prevent the compatibility from being provided internally, as required by the statute. As a result, we seek comment on potential solutions that would make wireless devices usable by persons with hearing aids without resorting to cumbersome or additional external devices.

Except for my comment above, shielding the troublesome parts of the wireless phone, or employing an electronic cancellation method are the only solutions to the interference problem, for phones that emit interference. I agree that it would not be in the public interest to require all phones to separate the earpiece from the transmitter. However, that is not the only solution. More careful design of the phone to reduce interference, or contain it if necessary, is another solution. It is not the transmitter of the phone per se that causes interference. It is the power surges that supply the transmitter, and the battery and wires to the transmitter could be designed to "cancel out" the radiation they produce or be shielded.

4. Effect Upon Marketability of Telephones

28. Fourth, we seek comment on whether compliance with the requirements of the rule would increase costs to such an extent that the telephones to which the exemption applies could not be successfully marketed. With respect to this criterion, we seek comment on the costs required for service providers and telephone manufacturers to make their products hearing aid compatible. Industry parties should address the extent to which costs would be increased and at what point such cost increases would begin to affect the marketability of covered telephones. Considering the learning curve effects and the economies of scale that would be involved with implementing hearing aid compatibility in the telephones, parties should estimate how quickly the cost of complying with the requirement could be expected to fall. How substitutable are alternative products that would not be subject to the hearing aid compatibility requirements? How price sensitive would the market be as a result of the changes?

The question should be divided into two questions: (1) How much does HAC cost? (2) How much would it cost to eliminate or reduce interference?

I observe that landline phones are available for less than $15 that are HAC, so the right kind of "speaker" that

emits electromagnetic speech signals (the compatibility signal) must not cost much. As I noted before, some very small phones may not have enough battery power to achieve a good level of HAC, so the cost of HAC would be more for them.

The cost of eliminating or reducing interference is another matter. It relates to the kind of network in use. I use a LG-510TM on the Verizon Network and have no interference as long as I am in a good signal area. I also tried the Samsung SCH3500 and SCH8500 on the Sprint network and had no interference in a good signal area. All three of these phones are the clamshell design, that places only the "speaker" part of the phone close to my telecoils. These three phones also exhibit a satisfactory level of HAC. I cannot say that they produce enough compatibility signal to satisfy part 68 rules, but the level is enough so I can use them in telecoil mode. Probably several other phones are available that operate on the Verizon or Sprint network that have very little interference even if they are not of the clamshell design.

On the other hand, the Nokia 6120 on the Bellsouth network has excessive interference even in a good cell tower signal area. The Bellsouth network is a different type of network.

Phones that operate on networks like Bellsouth need internal shielding or interference canceling techniques for troublesome components. The design work would probably be expensive, but production costs would be small.

REPORT
Digital Wireless Phone Interference to Hearing Aids

PART ONE - - SUBJECTIVE OBSERVATIONS

TITLE: Microphone Mode Observations

CELL PHONE: Nokia 6120 **HEARING AID: Oticon E39PL**
NETWORK: Cingular

These observations make a distinct difference in whether the hearing aid is in microphone mode or telecoil mode, and I use that distinction to draw some important conclusions. Microphone mode means the microphone of the hearing aid is the current input source, and the telecoil is not activated. Telecoil Mode means only the telecoil is the current input source and the microphone is not activated.

Observation #1: Microphone Mode

This observation is the way most people use cell phones, that is, with the phone held up to the ear, without any attachments. Some people who use hearing aids can use a cell phone this way, with the cell phone speaker held close to the hearing aid microphone. In my case, I found the interference to be excessive. That is, I can hear no speech and only hear interference which sounds like 60 hertz hum that we get from computer monitors, except the hum is more of a buzz and raspy sounding. It is much sharper than a hum and sounds like a series of pops in rapid succession. It is continuous and always present when the phone is in talk mode. My hearing loss is very severe and I have to use high power hearing aids to hear anything. People who do not have as severe a loss may not be bothered with the interference because their hearing aids are weaker.

Observation #2: Microphone Mode

In this observation, I plugged an external antenna in on the back side of the cell phone. This antenna is a magnetic mount antenna intended to be used on the top of an automobile. When the external antenna is plugged in, the built in antenna appears to be not connected. When using this arrangement, no interference was detected from the built-in antenna even when it was directly against the hearing aid. Interference was detected when the external antenna was brought close to the hearing aid, but when the external antenna was a few feet away from the hearing aid, no interference was detected. It appears that interference comes from the base of the antenna, not the tip. Speech was excellent as long as the external antenna was a few feet from the hearing aid.

PART ONE - - SUBJECTIVE OBSERVATIONS

TITLE: Microphone Mode Observations with Shielding

CELL PHONE: Nokia 6120 **HEARING AID: Oticon E39PL**
NETWORK: Cingular

Observation #3: Microphone Mode

I used the same set-up as in #1 above except I used a sample shield from "Wild NRG" between the cell phone and hearing aid. "Wild NRG" is a plastic shielding material intended to prevent harmful Cell Phone radiation to a human head. With this shield, I found the interference to be significantly reduced. I could hear speech, although it was not quite loud enough.. The shield blocked some of the acoustic sound. I also experimented with common metals as shields, with similar results. I used brass, tin, and copper. I understand that "Wild NRG" plans to market a "pouch" made of its exotic material that will enclose the entire cell phone except for the antenna. This may be useful for people who want to use their hearing aids in microphone mode with a cell phone.

PART ONE - - SUBJECTIVE OBSERVATIONS

TITLE: Telecoil Mode Observations & Conclusion

CELL PHONE: Nokia 6120 **HEARING AID: Oticon E39PL**
NETWORK: Cingular

Observation #4: Telecoil Mode

Using the cell phone's built-in antenna or an external antenna resulted in excessive interference and no speech at all. I know this particular cell phone is HAC (to some extent) because I can hear key beeps when the cell phone is not in talk mode. Occasionally I find the cell phone to be in analog mode and the interference is non-existent and speech is good and I can receive the speech signal in telecoil mode. But when the cell phone is operating in digital mode, interference is all I hear. The "Wild NRG" shield was not effective in telecoil mode. Using the external antenna was not effective, like it was when the hearing aid was in microphone mode.

Conclusions

From these observations, it is seems obvious that interference can be reduced to an acceptable level when a hearing aid is in microphone mode. Cell phone designs that place the antenna further from the hearing aid will help. Also shielding and a "clam shell" design will reduce interference to acceptable levels.

However, when a hearing aid is in telecoil mode, which is very important for many hearing aid users, interference is excessive, and it is of the common EMI that hearing aid users find from a lot of sources, such as computer monitors, fluorescent lights, and transformers.

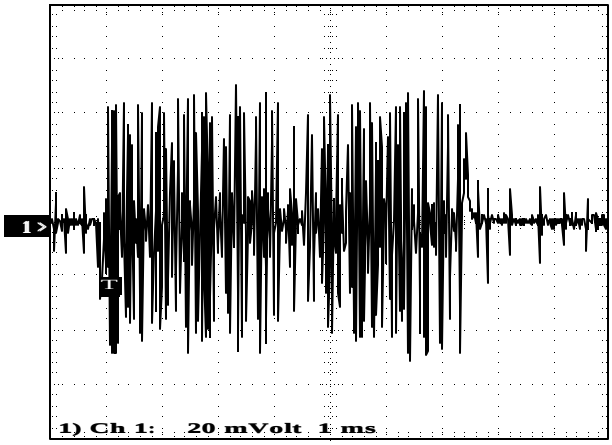
Interference is excessive in telecoil mode even when an external antenna is used. The interference is coming from the phone itself, not the antenna. This leads me to the conclusion that interference is not related to RF transmissions.

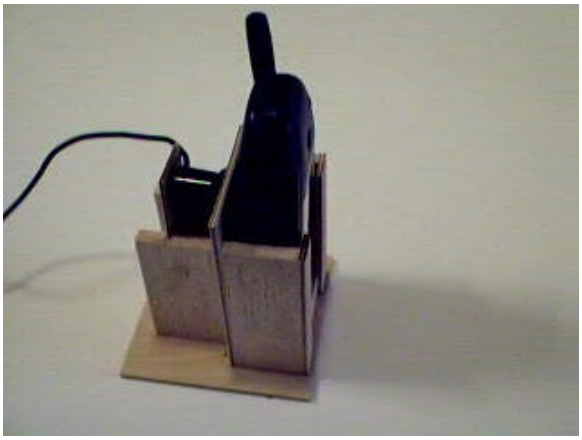
The “Wild NRG” shield is designed to reduce RF emissions, and since it was not very effective with the hearing aid in telecoil mode, this is another factor that leads me to the conclusion that interference is in the audio band and not in the RF band.

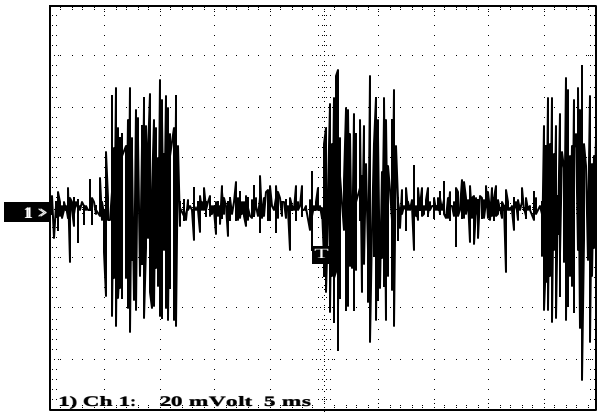
PART TWO - - OSCILLOSCOPE OBSERVATIONS

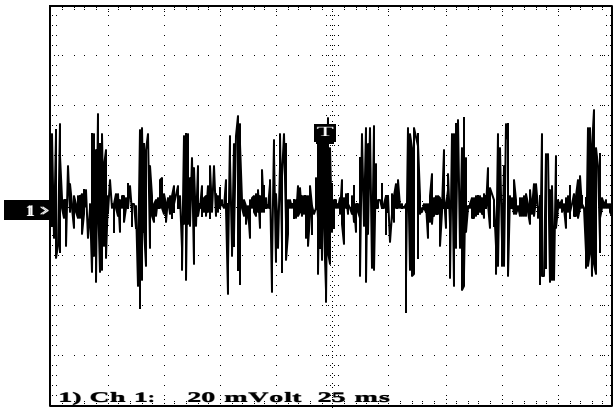
TITLE: Basic Set-Up

CELL PHONE: Nokia 6120 **INDUCTIVE PICKUP: Radio Shack Part # 44-533**
NETWORK: Cingular **OSCILLOSCOPE: Tektronix TDS 210**









These oscilloscope waveforms to the left show the signal received by an inductive pickup close to the back side of the phone. (See Photo) An inductive pickup is the same thing as a telecoil in a hearing aid. The interference signal was the strongest on the back side of the phone, not at the antenna.

Sensitivity of the scope was set at 20 mVolt per division with the pickup connected directly to channel 1 of the scope. All three waveforms are of exactly the same thing, but with horizontal times scales of 1 millisec, 5 millisec, and 25 millisec per division.

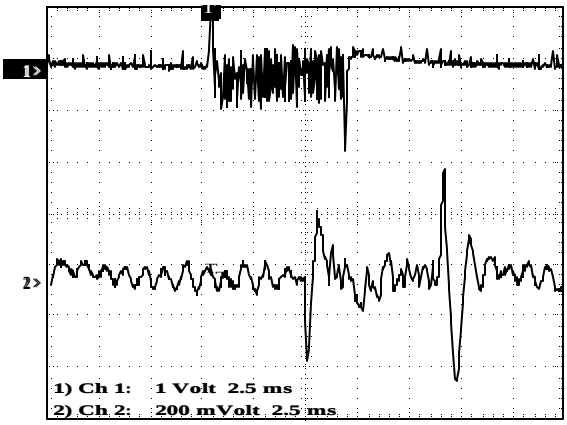
The first waveform, the one with a 1 millisec time scale, shows a burst of energy (interference) lasting for about 6.5 millisec. The second one shows that too, but it also shows a quiet time between bursts of about 13 millisec, and it shows the start of one burst to the start of the next is 20 millisec. That converts to a frequency of 50 Hz, which is what hearing aid users hear — a 50 Hz buzz.

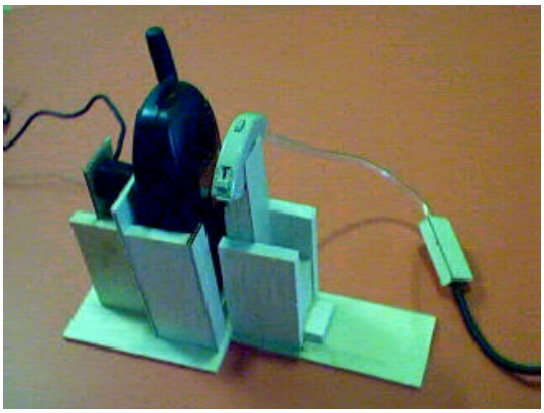
The third waveform shows that the buzz continues indefinitely, as long as the phone is in talk mode.

PART TWO - - OSCILLOSCOPE OBSERVATIONS

TITLE: Basic Set-Up With a Hearing Aid

CELL PHONE: Nokia 6120 **INDUCTIVE PICKUP: Radio Shack Part # 44-533**
NETWORK: Cingular **OSCILLOSCOPE: Tektronix TDS 210**
HEARING AID: Oticon E39PL





This scope picture shows two channels of information. (Two waveforms) Usually oscilloscopes are set up to show time on the horizontal axis and voltage (signal) on the vertical axis. Time flows from left to right. Even though each waveform can be set for different voltage scales, they share the same time scale, so what is shown is real time during this period of capture.

Channel one is just like the previous page except I connected the inductive pickup to an amplifier and the output of the amplifier is connected to channel one. I changed the voltage scale to 1 Volt. Channel two is the output of the hearing aid. Notice the photo shows that I removed the ear hook from the hearing aid and I inserted a plastic tube. The other end of the tubing feeds into a microphone and the microphone feeds into an amplifier and the amplifier feeds into channel two of the ‘scope.

I was playing a 1000 Hz tone to the cell phone during this time. I did this by placing a tone generator and speaker close to a cordless phone, and I called my cell phone from the cordless phone. Since real speech is a complex waveform, it is much better to use a simple signal for observing waveforms..

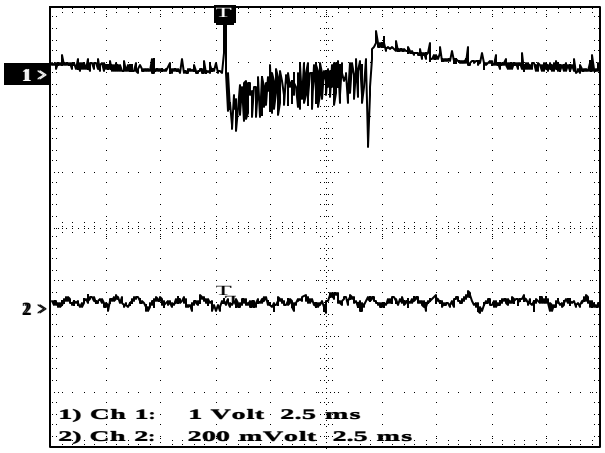
The hearing aid is in Microphone Mode.

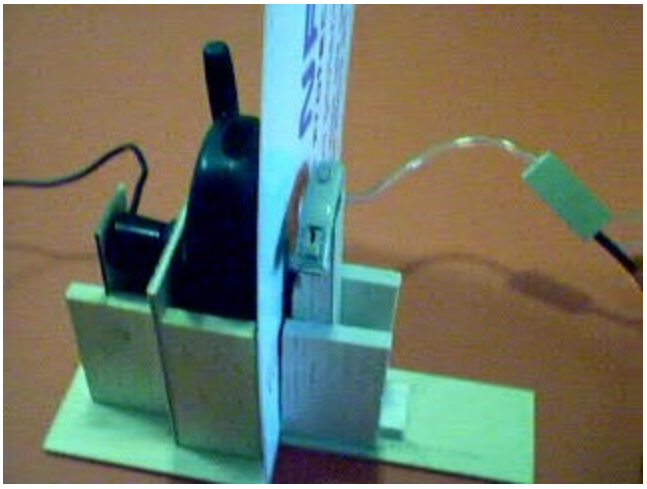
The 1000 Hz tone can be seen, on the waveform labeled “2”, but two large impulses occur at the start and stop of the interference burst. The impulses appear to be displaced downstream from the interference burst, but that is because I am using a plastic tube to transmit the sound from the hearing aid to a micro-phone, then to the 'scope. The displacement is about 5 millisec, which is the time it takes for sound to travel down the tube. The photo shows the physical arrangement, but I used a much shorter plastic tube to be able to get all the essential elements in the photo. I used a longer tube in the actual experiment so the microphone would be as far as possible from the cell phone. The tubing was about 60 inches long, which gives a transmission time of almost 5 millisec.

PART TWO - - OSCILLOSCOPE OBSERVATIONS

TITLE: Effect of Placing a Shield between the Cell Phone and the Hearing Aid

CELL PHONE: Nokia 6120 **INDUCTIVE PICKUP: Radio Shack Part # 44-533**
NETWORK: Cingular **OSCILLOSCOPE: Tektronix TDS 210**
HEARING AID: Oticon E39PL





The hearing aid is in Microphone Mode.

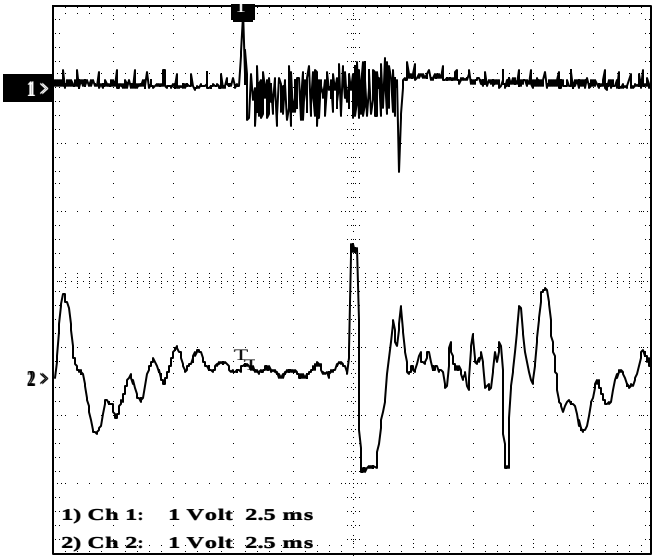
This is the very same setup as the previous page except I have inserted a shield, called “Wild NRG” between the cell phone and the hearing aid. The 1000 Hz tone is being played to the cell phone as before. I was careful to keep the hearing aid gain and the amplifier gain for the tubing microphone the same on both experiments.

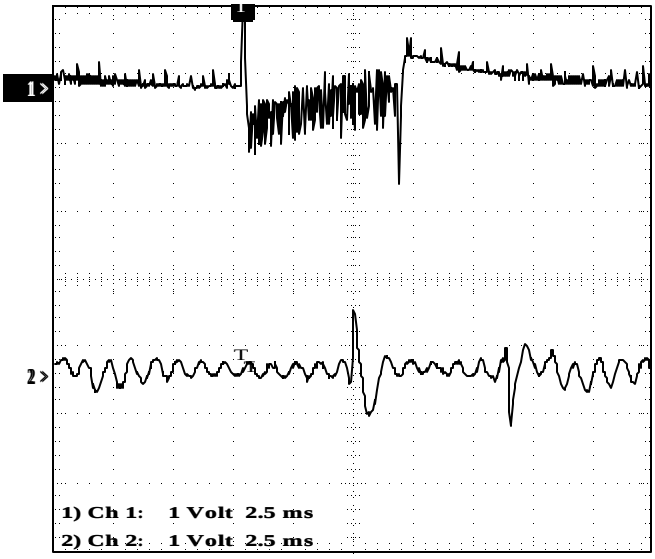
Notice the shield completely blocks the interference, but it also blocks some of the sound.
The sound shows as a very slight wiggle on waveform two. Blocking the sound is not an important consideration since shields could be designed to not interfere with the sound

PART TWO - - OSCILLOSCOPE OBSERVATIONS

TITLE: Effect of Shielding when Hearing Aid is in Telecoil Mode

CELL PHONE: Nokia 6120 **INDUCTIVE PICKUP: Radio Shack Part # 44-533**
NETWORK: Cingular **OSCILLOSCOPE: Tektronix TDS 210**
HEARING AID: Oticon E39PL





Hearing aid is in Telecoil Mode

Scope picture on the left is without a shield and on the right it is with “Wild NRG” shield. Same photo as on the previous page. The shield does reduce the interference a lot, but it is still there. I’m estimating from the right picture, the interference signal is 1 V and the speech signal (1000Hz tone) is .25V, which makes the interference about 4 times stronger than the speech signal. Of course, the signal levels are relative and not absolute because I used an amplifier between the tubing microphone and the ‘scope. I was careful to not change the gain on the hearing aid nor the tubing amplifier in all these measurements.

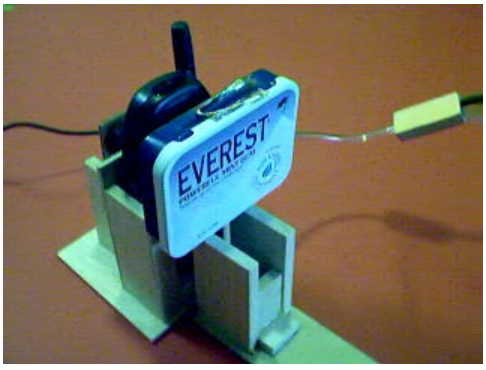
Notice that I reduced the voltage scale on channel two from 200 mVolts to 1 V. This was necessary with the hearing aid in telecoil mode because the ‘scope waveform went off the screen. As long as I have a printout and a record of the voltage settings I can compare apples to apples.

PART TWO - - OSCILLOSCOPE OBSERVATIONS

TITLE: Photos of Hearing Aid in a Box

CELL PHONE: Nokia 6120
NETWORK: Cingular
HEARING AID: Oticon E39PL

INDUCTIVE PICKUP: Radio Shack Part # 44-533
OSCILLOSCOPE: Tektronix TDS 210



In this experiment, I placed my hearing aid inside a mint box. I wanted to see what effect total shielding would have on interference. The photo does not show it very well, but I made a connection to the signal ground of the hearing aid to the box. I also soldered a wire between the back of the box and it's top, since the top is rather loose fitting and hinges onto the bottom.

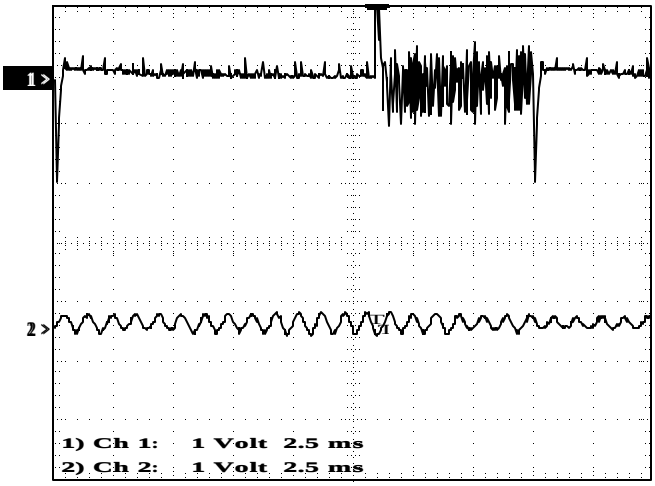
The hearing aid is held in place with foam rubber and the plastic tubing goes through a hole in the box to the sound output of the hearing aid. A microphone is used as before to receive the sound from the tubing.

The third photo shows the box in position in front of the cell phone.

PART TWO - - OSCILLOSCOPE OBSERVATIONS

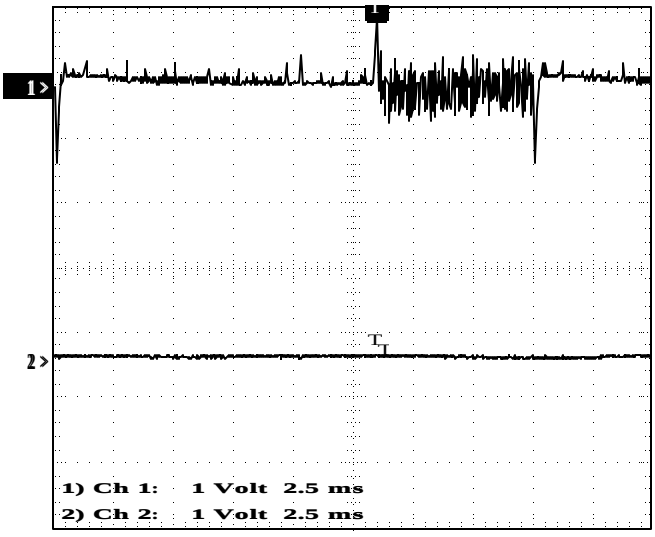
TITLE: Effect of Shielding the Hearing Aid (Hearing Aid in a Box)

CELL PHONE: Nokia 6120 **INDUCTIVE PICKUP: Radio Shack Part # 44-533**
NETWORK: Cingular **OSCILLOSCOPE: Tektronix TDS 210**
HEARING AID: Oticon E39PL



Hearing aid inside the box, in Microphone Mode.

Notice there is no interference signal at all on channel two, which is the output of the hearing aid. There is speech signal (1000 Hz tone) because some sound comes through the tin box.



Hearing aid inside the box, in Telecoil Mode.

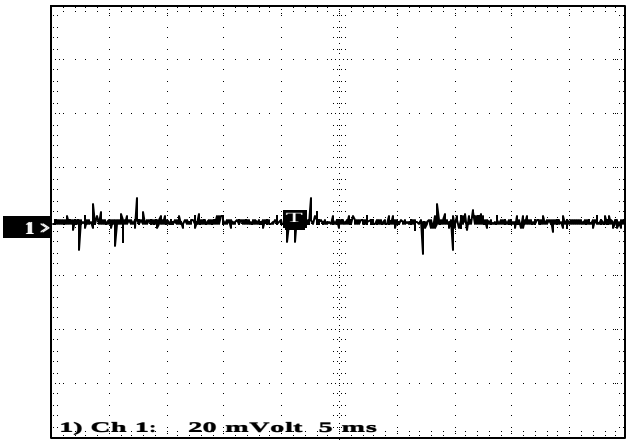
Notice that shielding completely stops the interference even in telecoil mode, but there is no speech signal either. Shielding the hearing aid is like throwing the baby out with the bath water!

That's because the telecoil has to be unshielded to receive anything and interference signals from digital cell phones are the kind of signals telecoils like the best!

PART TWO - - OSCILLOSCOPE OBSERVATIONS

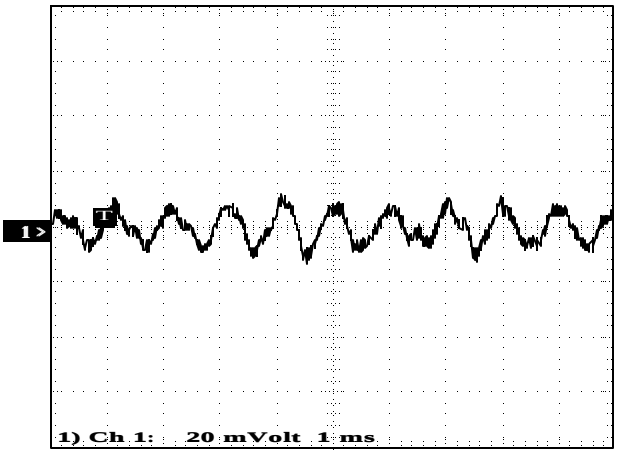
TITLE: A Digital Wireless Phone with Little Interference

CELL PHONE: LG-510TM **INDUCTIVE PICKUP: Radio Shack Part # 44-533**
NETWORK: Verizon Wireless **OSCILLOSCOPE: Tektronix TDS 210**
HEARING AID: Not used



LG-510TM on the Verizon network. There is very little interference as can be seen from this waveform, and I can use this phone with my hearing aids set to telecoil mode. When I am in a fringe area for the Verizon Network, I hear a popping sound, not a buzz.

The waveform shows small spurious spikes. I held the inductive pickup directly on the battery of the cell phone to get this waveform. A future experiment is to move my test equipment to a better signal area and see if the spikes go away.



This waveform is from holding the inductive pickup directly over the "speaker" of the cell phone, while playing a 1000 Hz tone to the cell phone.

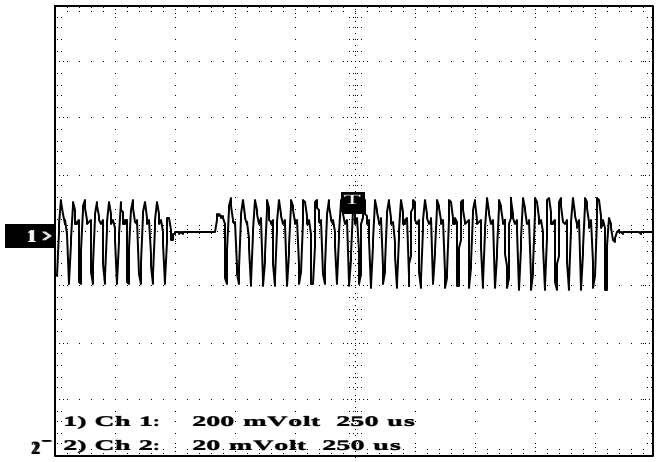
The spikes in the above waveform are not present. I was never able to use the inductive pickup at the speaker with the Nokia phone. There was not enough speech signal from the inductive pickup itself to register on the 'scope in the presence of the interference signal. That is the reason I used my hearing aid as a test device.

Although I did not record the interference from them, I tried the Samsung SCH8500 and SCH3500 on the Sprint network. Interference was almost non-existent and both phones exhibited a good level of HAC.

PART TWO - - OSCILLOSCOPE OBSERVATIONS

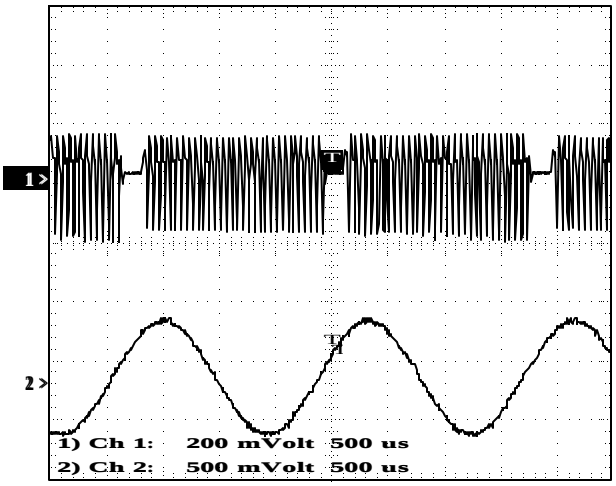
TITLE: Interference from the Display Backlight

CELL PHONE: Samsung SCH8500 **INDUCTIVE PICKUP: Radio Shack Part # 44-533**
NETWORK: Sprint **OSCILLOSCOPE: Tektronix TDS 210**
HEARING AID: Not used



Interference from a Samsung SCH8500 due to the display backlight. LG-510TM has the same problem. This interference is non-existent if I turn the display backlight off… but sometimes I need the backlight.

The waveform is a string of 32 pulses 50 Microseconds apart, followed by a dead time of 250 Microseconds. Pulses 50 Microsec apart are a much higher frequency than I can hear. (20 KHz) It is the gaps in the string of pulses that create a sound in my hearing aids.



Waveform on channel one is the same as above except with a 500 Microsec time scale. The waveform on channel two is from my signal generator. I put both signals on the scope at the same time so I could confirm that the display backlight sounds like a "XX" Hz tone.

While watching the 'scope, I changed the frequency of the signal generator until the waveform on channel 2 "synced in" and became stable with the waveform on channel one. As can been seen from 'scope picture, XX is about 700 Hz and it matches with the "gaps" in the string of pulses from the backlight.

The dark areas on waveform one are not significant and they are just characteristic of the 'scope used at this time scale.

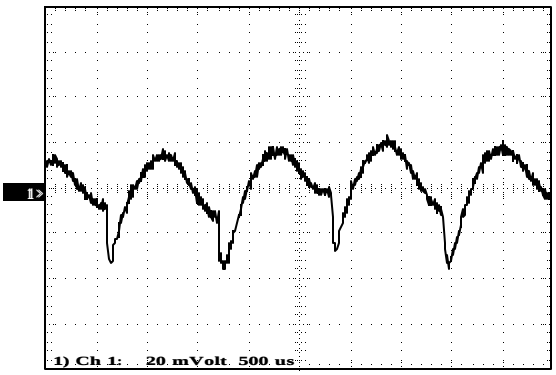
Cell phone manufacturers could do a better job of containing this type of interference.

PART TWO - - OSCILLOSCOPE OBSERVATIONS

TITLE: Interference from an Electric Toothbrush!

CELL PHONE: Not used
NETWORK: Not used
HEARING AID: Not used

INDUCTIVE PICKUP: Radio Shack Part # 44-533
OSCILLOSCOPE: Tektronix TDS 210



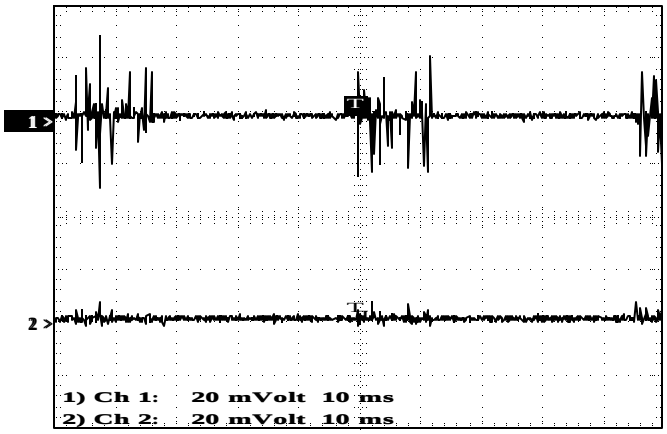
I included this scope picture to show that simple things that do not involve 900 MHz nor 1800Mhz wireless communication also emit the same kind of interference. I used the same inductive pickup, which simulates a hearing aid telecoil, with the scope set for the same sensitivity as I did for the phone scope pictures. The frequency of the interference is in the ball park as the frequency of cell phone interference. (Audio range) The signal strength is about the same.

When I hold the toothbrush up next to my hearing aid in telecoil mode, I hear a nice, loud, tone.

PART TWO - - OSCILLOSCOPE OBSERVATIONS

TITLE: Effect of Separating the Battery from the Phone

CELL PHONE: Nokia 6120 **INDUCTIVE PICKUP: Radio Shack Part # 44-533**
NETWORK: Cingular **OSCILLOSCOPE: Tektronix TDS 210**
HEARING AID: Not Used

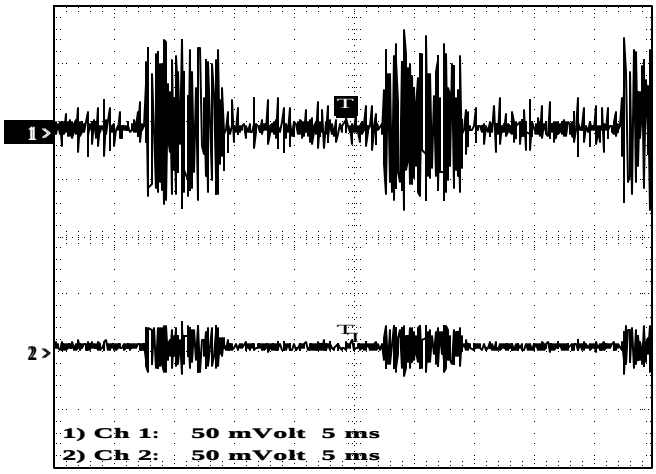


In this experiment, I removed the battery from the phone and connected the battery to the phone with a 36 inch cable.

Channel 1 waveform is from an inductive pickup next to the battery. The pickup was connected directly to channel 1 without an amplifier.

Channel 2 waveform is a second inductive pickup (no amplifier) next to the phone, in the area where the battery goes.

The phone is not in talk mode, but is on standby. Notice the interference signal is very strong from the battery and practically non-existent from the phone.



Phone is in talk mode.

Same setup as above, except I changed the 'scope sensitivity to 50 mVolt/Div. I can't explain why the signal strength is so much stronger than pictures on page 12.

As can be seen, the interference is much stronger from the battery.

The cable I used to connect the battery to the phone was not a shielded cable, and a future experiment is to use a shielded cable to see if relative signal strengths will change. I suspect some of the interference signal strength on waveform two is from the cable rather than the phone.

PART TWO - - OSCILLOSCOPE OBSERVATIONS

TITLE: Conclusions

CELL PHONE: N/A
NETWORK: N/A
HEARING AID: N/A

INDUCTIVE PICKUP: Radio Shack Part # 44-533
OSCILLOSCOPE: Tektronix TDS 210

When a hearing aid is in telecoil mode, which is the only mode that matters in a discussion about HAC, the primary source of interference from digital wireless phones is the power supply and associated wiring to the transmitter.

The interference waveform is roughly a 50 Hz On/Off sequence and has little to do with the RF transmission of the phone to the cell tower.

Immunizing or shielding the hearing aid is a fruitless effort because the telecoil has to be unshielded to be able to receive speech signals, and the interference signal is the same as a speech signal, except lower in frequency.